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Indian Standard

PROCEDURE FOR DESIGNING AIR CONDITIONING SYSTEM ON BOARD SHIPS

PART I HEAT LOAD CALCULATION

UDC 628·84 : 629·12·065

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PROCEDURE FOR DESIGNING AIR CONDITIONING SYSTEM ON BOARD SHIPS

PART I HEAT LOAD CALCULATION

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Indian Standard

PROCEDURE FOR DESIGNING AIR CONDITIONING SYSTEM ON BOARD SHIPS

PART I HEAT LOAD CALCULATION

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 30 September 1977, after the draft finalized by the Shipbuilding Sectional Committee had been approved by the Marine, Cargo Movement and Packaging Division Council.

0.2 As compared to the conditions ashore, the structure of a ship is complex, accommodation on board ships is compact, there are frequent changes in ambient conditions and also in the orientation of the ship with respect to the sun. Therefore, for determining the capacity of an air conditioning plant on board ship, the exact calculations of heat load are extremely difficult but the method of calculation can be based on scientific principles to meet with the practical requirements. A correct evaluation of the sensible heat load is essential for calculating the air quantity required for cooling or heating.

0.3 Considerable assistance has been derived from the Shipbuilding Standard VIS 376 E 1968 'Air conditioning — condition and calculation fundamentals', issued by the Swedish Shipbuilders Standard Centre.

0.4 This standard is a part of the series of Indian Standards on marine air conditioning, and is based on the practices followed in this country.

0.4.1 Other standards in the series of marine air conditioning are as follows:

IS : 8434-1977 Air conditioning requirements on board ships

General requirements for insulation in air-conditioned spaces on boardships (*under preparation*)

Tests, trials and certification of shipboard air conditioning system (*under preparation*)

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part I) prescribes the calculation method for the heat load on an air conditioning plant on board ship. It covers normal conditions which occur in all waters except conditions in extreme cold water in winter.

2. CONDITIONS

2.1 The conditions governing the calculations shall be as prescribed in IS : 8434-1977†.

2.2 The air conditioning system is to be designed to meet the primary and secondary conditions of the ambient air as specified in IS : 8434-1977†. The cooling coil shall be designed for primary conditions with 20 percent extra to meet service conditions.

3. HEAT GAIN AND HEAT LOSS

3.1 Summer — The calculations for heat gain shall be based on the following:

a) Transmission,
b) Solar heat,
c) Heat from personnel,
d) Heat from lighting and other sources, and
e) Heat due to supply of fresh air.

3.2 Winter — The calculation for heat loss shall be based on the total transmission loss. Solar heat gain, heat from personnel and the heat gain from lighting and other sources, if any, are not to be included.

NOTE — A worked-out example is given in Appendix A.

4. TRANSMISSION

4.1 Structural Heat Transmission (Q_t) — This is due to the difference in air temperature on the two sides of the boundary surfaces of an air conditioned space, and shall be calculated according to the following expression:

$$Q_t = \Sigma A.U.\Delta t$$

---

*Rules for rounding off numerical values (*revised*).

†Air conditioning requirements on board ships.

where

Q_t = total structural transmission, W;
A = surface area, m^2;
U = heat transmission coefficient, W/m^2 K (*see* Table 2); and
Δt = temperature difference between room and adjoining non-air conditioned space, °C (*see* Table 1).

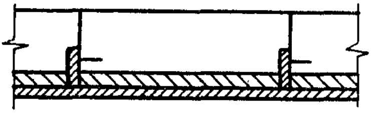
4.1.1 *Temperatures in Adjoining Spaces* — The difference in temperature between non-air conditioned spaces and the air conditioned spaces shall be considered as prescribed in Table 1.

4.2 Heat Transmission Coefficient (U) — The heat transmission coefficient shall be calculated according to the following expression:

$$\frac{1}{U} = \sum\frac{1}{\alpha} + \frac{\sum\frac{d}{\lambda} + m_l + m_b}{\mu}$$

where

U = heat transmission coefficient, W/m^2 K;
α = surface to air heat transfer coefficient, W/m^2 K;
= 81 W/m^2 K for surfaces exposed to wind with a speed of 20 m/s;
= 8 W/m^2 K for surfaces not exposed to wind with a speed of 0·5 m/s;
d = thickness of material, m;
λ = thermal conductivity of material, W/m K;
m_l = heat resistance in air layer, m^2 K/W;
m_b = contact resistance between different layers of materials, m^2 K/W;
= 0·086 m^2 K/W;
μ = 1·2 for type of insulation as in figure below:



μ = 1·45 for type of insulation as in figure below:

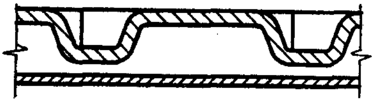


TABLE 1 TEMPERATURE DIFFERENCE BETWEEN NON-AIR CONDITIONED AND AIR CONDITIONED SPACE

(*Clause* 4.1 *and* 4.1 1)

SL No.	SURFACE AGAINST ADJOINING SPACE	SUMMER $(t_a - t_i)$°C	WINTER $(t_i - t_a)$°C
(1)	(2)	(3)	(4)
i)	Deck above hot tanks	41	17
ii)	Deck and bulkhead against boiler room	26	17
iii)	Deck and bulkhead against engine room and non-air conditioned galley	16	17
iv)	Deck and bulkhead against cargo space and equivalent spaces	11	37
v)	Deck and bulkhead against laundry	11	17
vi)	Deck and bulkhead against common sanitary spaces	6	0
vii)	Deck and bulkhead against private sanitary spaces:		
	a) With any part against exposed outer surface	2	0
	b) Not-exposed	1	0
viii)	Bulkhead against alleyway adjoining engine room or boiler room	3	6
ix)	Bulkhead against alleyway not adjoining engine room or boiler room	2	8

NOTE — t_a = temperature in adjoining space, t_i = temperature in air conditioned space.

4.3 Surfaces — The measurements shall be made from steel to steel for calculation of the transmission surfaces.

4.4 The maximum value of heat transmission coefficient for insulation for different cases shall be as prescribed in Table 2.

TABLE 2 HEAT TRANSMISSION COEFFICIENT

(*Clauses* 4.1, 4.4 *and* 5.1)

SL No.	SURFACE	HEAT TRANSMISSION COEFFICIENT (U-VALUE) W/m² K
(1)	(2)	(3)
i)	Glass windows	4·7
ii)	Bulkhead against alleyway	2·3
iii)	Ship's side, outer bulkhead or weather deck with sun awning	0·9
iv)	Deck and bulkhead against engine room, cargo space or other non-air conditioned spaces	0·8
v)	Deck and bulkhead against boiler room or near boiler or engine room	0·7
vi)	Deck against open air or weather deck without sun awning and deck above hot tanks	0·6

5. SOLAR HEAT GAIN

5.1 The solar heat gain shall be calculated according to the following expression:

$$Q_s = A_s.U.\Delta t + A_g.G_s$$

where

Q_s = solar heat gain, W;

A_s = surface exposed to sun radiation excluding glass window, m^2;

U = heat transmission coefficient for the surface, W/m^2K (*see* Table 2);

Δt = excess temperature, °C (above the outside temperature) caused by sun radiation according to the following:

Time	0800 h	1000 h	1200 h
Horizontal surface	14°C	25°C	30°C
Vertical dark surface	28°C	18°C	—
Vertical light surface	14°C	9°C	—

A_g = free sunlit glass surface of window, m^2; and

G_s = heat gain through glass.

NOTE 1 — The average heat gain may be taken as 313 W/m^2 for glass surface.

NOTE 2 — Surface under shadow caused due to projected deck, permanent deck awning or any other deckhouse structure shall not be included in A_s.

5.1.1 The angle of incidence of sun radiation in relation to horizontal plane shall be considered as follows:

Time	*Angle of Incidence*
0800 h	30°
1000 h	60°
1200 h	90°

6. HEAT FROM PERSONNEL

6.1 The sensible and the latent heat gain from personnel which are functions of the temperature in the spaces shall be calculated from Fig. 1.

NOTE — The latent heat and sensible heat expressed in this figure refer to normal scale. For active scale the value shall be normal value plus 10 percent.

6.2 Number of Persons

6.2.1 *Cabins* — Maximum number of persons expected to live in the cabin shall be considered.

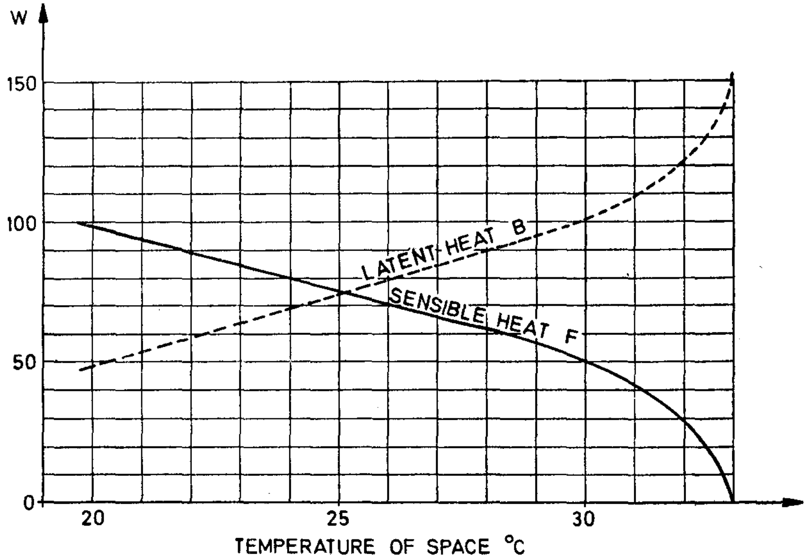


Fig. 1

6.2.2 *Saloons, Mess Rooms and Day Rooms* — Number of persons who can be seated in the space concerned shall be considered. When this is not indicated the following scale shall be used:

Saloons	1 person per 1·0 m^2 floor surface
Officers' mess	1 person per 1·0 m^2 floor surface
Crew's mess	1 person per 0·7 m^2 floor surface

6.2.3 Master's and chief engineer's day rooms shall be considered for occupation by four persons each.

6.2.4 First mate, second engineer, chief steward and other similar personnel's day rooms shall be considered for use by three persons each.

6.2.5 *Hospital Cabins* — The number of persons shall be calculated as the number of beds plus two.

7. LIGHTING AND OTHER HEAT GAIN

7.1 In the spaces which have no natural light (spaces without side lights or windows) the heat from lighting in the space shall be calculated in addition to a possible transmission and solar heat gain. The heat gain from lighting shall be calculated at the same value as the output of the light fittings. When this is not stated, heat from lighting shall be calculated as 6 W per m^2 floor surface. In the case of fluorescent light 20 percent extra shall be taken into consideration.

7.2 The radio cabin shall be calculated with a heat gain of 600 W from apparatus installed in the cabin, with the assumption that a separate exhaust duct is installed to lead away heat from the wireless transmitter. Otherwise a total heat equivalent to the total power of the radio equipment shall be taken into consideration.

7.3 The following items have also to be considered in the calculation:

a) Heat gain in fan, which gives a rise in the temperature of the air of about 1°C/100 mmH_2O gauge; and

b) Temperature rise in air ducts during dissemination of air to the supply points of about 2°C.

NOTE — Furniture, wardrobes, etc, are not to be considered in calculation of the volume of cabins and other spaces.

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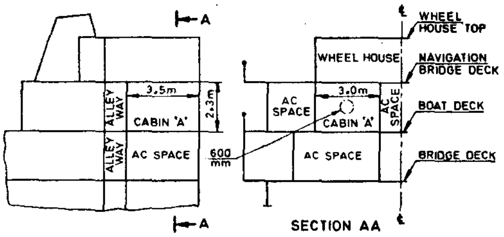
APPENDIX A

(*Clause* 3.2)

SPECIMEN HEAT LOAD CALCULATIONS



Cabin No. A	Space Third Engineer	No. of Persons : 1	
Length — 3·5 m	Breadth — 3 m	Height — 2·3 m	Ag — 0·28 m²

A. Structural Transmission

Boundary Surface	Dimension m	Area m²	U W/m²K	Winter		Summer		Heat Load, W
				Δt°C	Q_t, W	Δt°C	Q_t, W	
Deck against wheelhouse	3·5 × 3	10·50	0·8	8	67	2	17	
Bulkhead against alleyway	3 × 2·3	6·90	2·3	6	96	3	48	
Outer bulkhead minus glass window	(3 × 2·3) – 0·6 dia	6·62	0·9	40	238	7	42	
Glass window	0·6 dia	0·28	4·7	40	53	7	9	
				Total Structural transmission	454		116	116

B. Solar Heat

Time	Sun Elevation	Shaded Height = Overhang × tan θ	Vertical Sunlit Area Excluding Glass Window					Sunlit Glass			
			Dimension, m	A_s, m²	U, W/m²K	Δt°C	Q_s, W	Ag, m²	G_s, W/m²	Q_s, W	
0800 h	30°	—	(3 × 2·3) – 0·6 dia	6·62	0·9	14	83	0·28	313	88	
1000 h	60°	—	(3 × 2·3) – 0·6 dia	6·62	0·9	9	54	0·28	313	88	
Time	Sun Elevation	Shaded Length or Breadth of Deck	Horizontal Sunlit Area								
			Dimension, m	A_s, m²	U, W/m²K	Δt°C	Q_s, W				
0800 h	30°	—	—	—	—	14	—				
1000 h	60°	—	—	—	—	25	—				
1200 h	90°	—	—	—	—	30	—				
									Total solar heat = 83 + 88 = 171 W		171

C. Heat from Personnel and Other Sources

Source	Category	No.	Rate, W	Sensible Heat, W	
Occupants	Seated	1	60	60	
Occupants	Active	—	—	—	
Light, fluorescent, bulbs, appliances, etc	—	—		(10·5 × 6) × 1·2 = 76	
		Lights being off at peak period.		Total sensible heat (summer) = 60 W	60
Source	**Category**	**No.**	**Rate, W**	**Latent Heat, W**	
Occupants	Seated	1	90	90	
Occupants	Active	—	—	—	
Appliances	—	—	—	—	
				Total Latent heat (Summer) = 90 W	90
				Total cabin heat load (Summer)	437